

## **USING LINEAR PROGRAMMING WITH REFINERY SIMULATION**

Johan Janse van Rensburg

Group Technology  
Sasol Limited  
1 Klasie Havenga st.  
Sasolburg, 1948, South Africa

### **ABSTRACT**

Linear programming is used in the planning and scheduling of crude oil refineries. While being an important tool the linear program has some limitations. To test the feasibility of the linear program, computer simulation modelling is used which can closely approximate the refinery process. The linear program output is used in the simulation for product flow. Simulation is able to accurately model variability and tank storage. The combination of these techniques better reflects refinery complexity when assessing fuel product trade-offs. Using an Internal LP solver in the simulation model or using an external Solver is compared while the practical implementation in refinery business cases is discussed.

### **1 INTRODUCTION**

Crude oil consists of a mixture of chemical components which are mostly hydrocarbons. Crude oil refineries split crude oil into components which are stored in tanks before they are used in the blending of fuel products. A refinery consists of a number of different units, for example distillation and fractionation columns and is a continuous production system. The units have a range of operating parameters which deliver different product volumes and specifications. Government legislation and quality standards determine the specifications for fuel products.

### **2 LINEAR PROGRAMMING**

A refinery linear program (RLP) is used to route the flow of chemical components through the different units in the refinery and as a planning tool for product delivery while satisfying the fuel specifications. The fuel specification calculations are inherently non-linear and the RLP approximate these by linearizing the calculations.

RLP approximates the unit maintenance and breakdowns with unit availability as a percentage.. The output of the RLP is a hourly average production of the refinery and the different units.

RLP do not take variability and tanks into consideration which could be a bottleneck in the refinery.

### **3 REFINERY SIMULATION MODEL**

A refinery simulation model is used to test the feasibility of the RLP results. The simulation models the units, tanks, maintenance and breakdowns in more detail. The simulation model is also used to simulate the hourly fuel demand

To blend the fuel products and to adhere to the fuel specifications a linear program (LP) is used. The LP can either be built into the simulation or be called externally by using for example the Microsoft Excel solver. Using the Microsoft Excel solver allows for using non-linear constraints while with the internal LP only linear calculations can be used. As starting point for the LP the RLP blend recipe is used. The blend recipe of the LP is used in the simulation for the blending of fuel products.

The production of the units pushes component volume into the component tanks and if these tanks reach their capacity limit production must stop. There must always be space in these tanks for the unit rundowns because stopping and starting a unit is not a quick or straight forward process. The demand for specific fuel products drives the blending process. Different fuel components are mixed and stored in final product tanks. These tanks are certified as being on specification before they can be distributed to clients.

#### **4 CONCLUSIONS**

The presentation will discuss the methods of using a LP with the simulation of blending fuel products in a refinery. The focus will be on the implementation, some of the pros and cons and simulation time of the two LP versions.